(12) UK Patent Application (19) GB (11) 2 314 988 (13) A

(43) Date of A Publication 14.01.1998

(21) Application No 9713681.6

(22) Date of Filing 27.06.1997

(30) Priority Data
(31) 9616528 (32) 06.08.1996 (33) GB
9613918 03.07.1996

(51) INT CL[6]
H04N 3/36 5/253 9/11

(52) UK CL (Edition P)
H4F FCD FD1B9 FD12K9 FD27C1 FD27S FD30P FD53C FD81P FHHX

(56) Documents Cited
GB 2249930 A GB 1566910 A DE 002525073 A1

(58) Field of Search
UK CL (Edition O) H4F FCD FHHB FHHX
INT CL[6] H04N 3/36 3/38 3/40 5/253 5/257 9/11
Online: WPI

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(54) **Film scanner illumination corrector**

(57) An illumination corrector for a flying spot (CRT 10) film scanner such as a telecine or film writer has additional light sensors 55,57,59 which detect light unmodulated by film. The additional sensors produce correction signals at each wavelength to allow for light variations which are coloured to be independently corrected in each colour channel. An embodiment has three additional sensors to allow independent correction of red, green and blue channels. The additional light sensors require no automatic gain control and may thus correct for slower light fluctuations in comparison to the prior art.

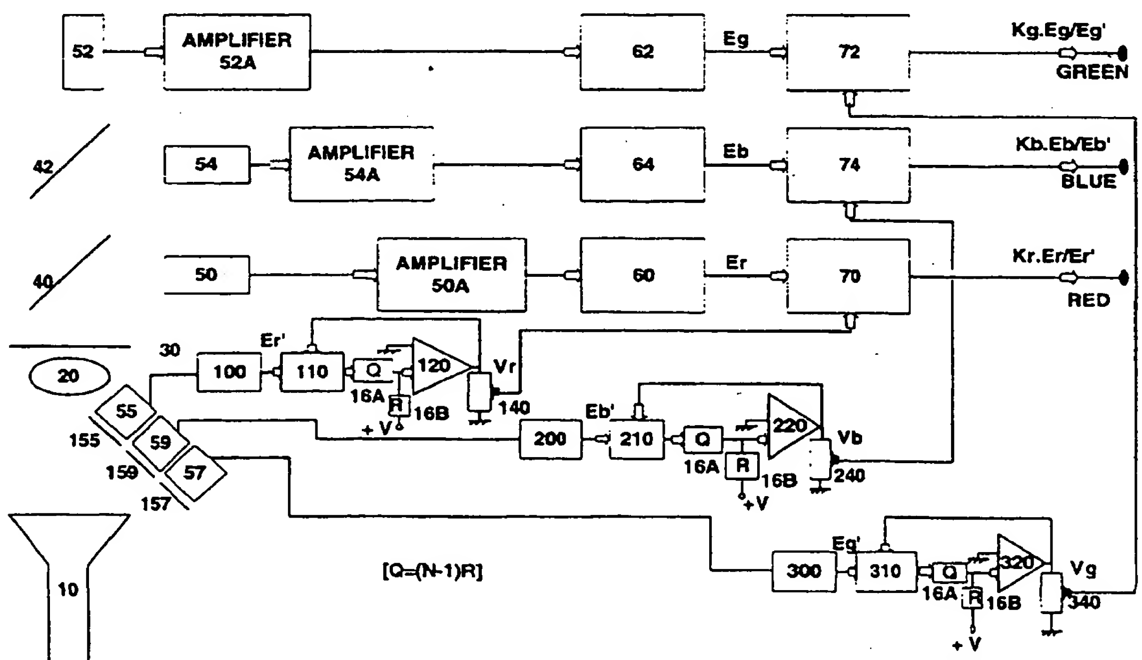

Fig. 2.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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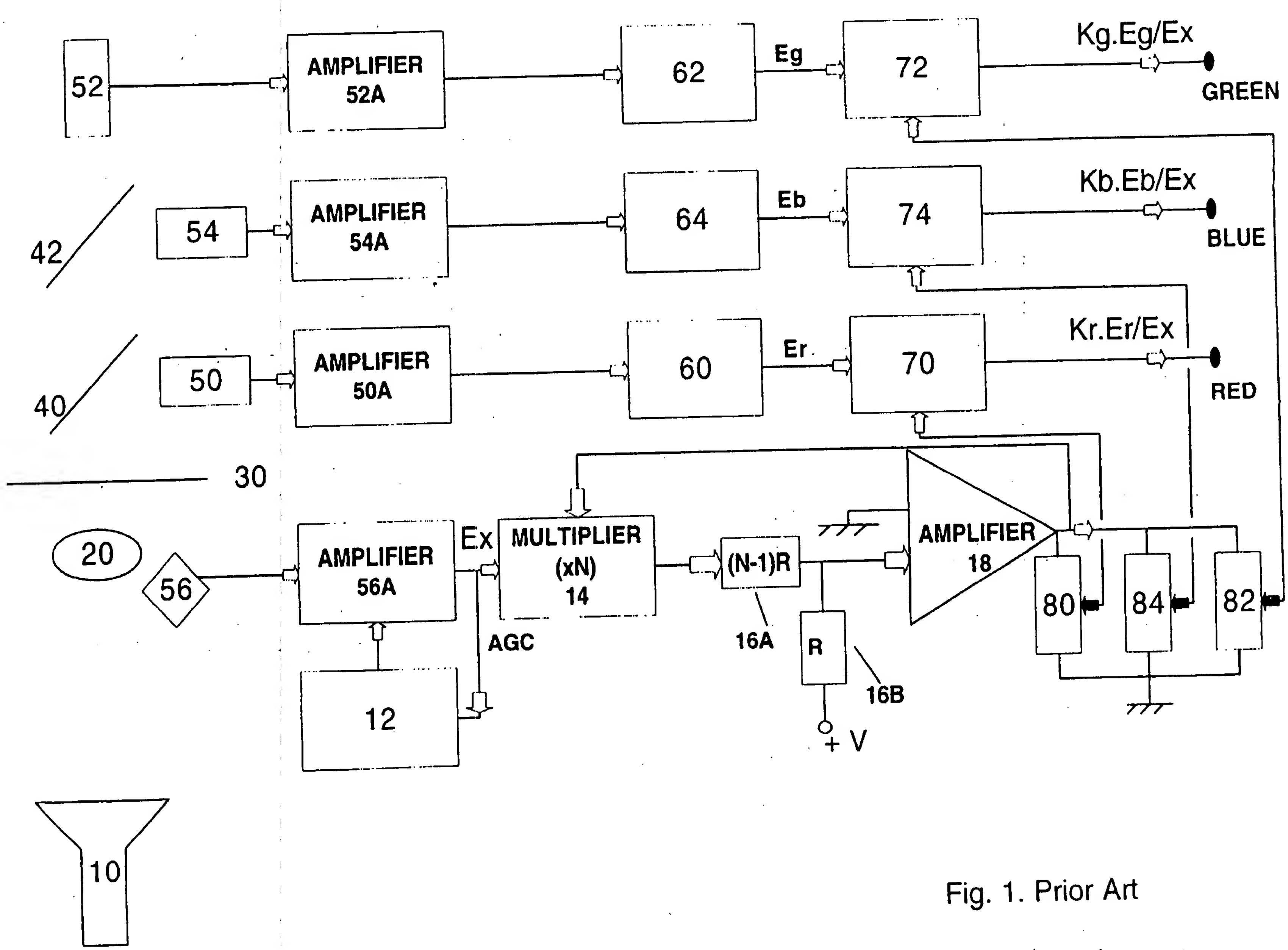

Fig. 1. Prior Art

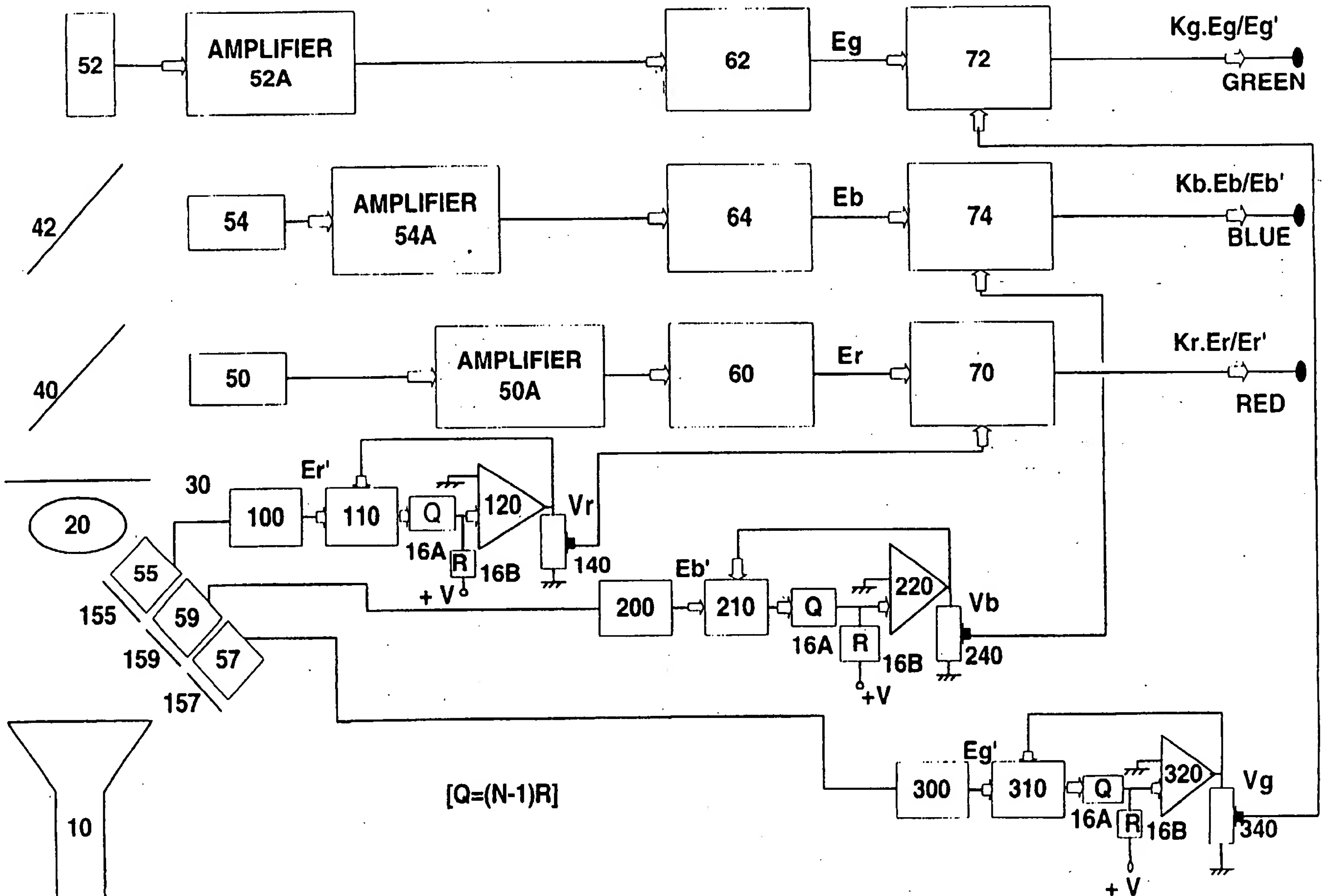
52
AMPLIFIER
52A
62
Eg
72
Kg.Eg/Eg'
GREEN
42
54
AMPLIFIER
54A
64
Eb
74
Kb.Eb/Eb'
BLUE
40
50
AMPLIFIER
50A
60
Er
70
Kr.Er/Er'
RED
30
20
Er'
100
110
Q
120
Vr
16A
R
16B
140
+ V
55
155
59
159
57
157
10
Eb'
200
210
Q
220
Vb
16A
R
16B
240
+V
[Q=(N-1)R]
Eg'
300
310
Q
320
Vg
16A
R
16B
340
+ V

Fig. 2.

Fig. 3

REFERENCE	CAUSE OF ILLUMINATION VARIATION	SINGLE PHOTOMULTIPLIER CORRECTION SENSOR	TRIPLE PHOTOMULTIPLIER CORRECTION SENSOR	EMBODIMENT OF THE INVENTION CAPABILITY
A.	Brightness reduction due to previous scan patches	Corrected	Improved correction compared to single PMT sensor	Improved correction compared to single PMT sensor
B.	Granularity of the Cathode Ray Tube	Corrected with C. But not D.	Improved correction compared to single PMT sensor	Improved correction compared to single PMT sensor
C.	Blemishes in the Cathode Ray Tube Phospor	Corrected with B. But not D.	Improved correction compared to single PMT sensor	Improved correction compared to single PMT sensor
D.	Dirt on the Cathode Ray Tube faceplate	Corrected But not C. or D.	Improved correction compared to single PMT sensor	Improved correction compared to single PMT sensor
E.	Changes of Brightness with time and temperature	Not corrected	Not corrected	Corrected
F.	Temporary brightness changes due to prior small scan patches	Not corrected	Not corrected	Corrected
G.	Changes in Brightness due to focus changes and drift	Not corrected	Not corrected	Corrected
H.	General non-uniformity of the CRT screen brightness	Corrected	Improved correction compared to single PMT sensor	Improved correction compared to single PMT sensor

NOTE: PMT = Photomultiplier Tube

TABLE 1.

REFERENCE	CAUSE OF ILLUMINATION VARIATION	SINGLE AVALANCHE PHOTO DIODE CORRECTION SENSOR
A.	Brightness reduction due to previous scan patches	Corrected
B.	Granularity of the Cathode Ray Tube	Corrected with C. But not D.
C.	Blemishes in the Cathode Ray Tube Phospor	Corrected with B. But not D.
D.	Dirt on the Cathode Ray Tube faceplate	Corrected But not C. or D.
E.	Changes of Brightness with time and temperature	Corrected
F.	Temporary brightness changes due to prior small scan patches	Corrected
G.	Changes in Brightness due to focus changes and drift	Corrected
H.	General non-uniformity of the CRT screen brightness	Corrected

Fig. 4

TABLE 2

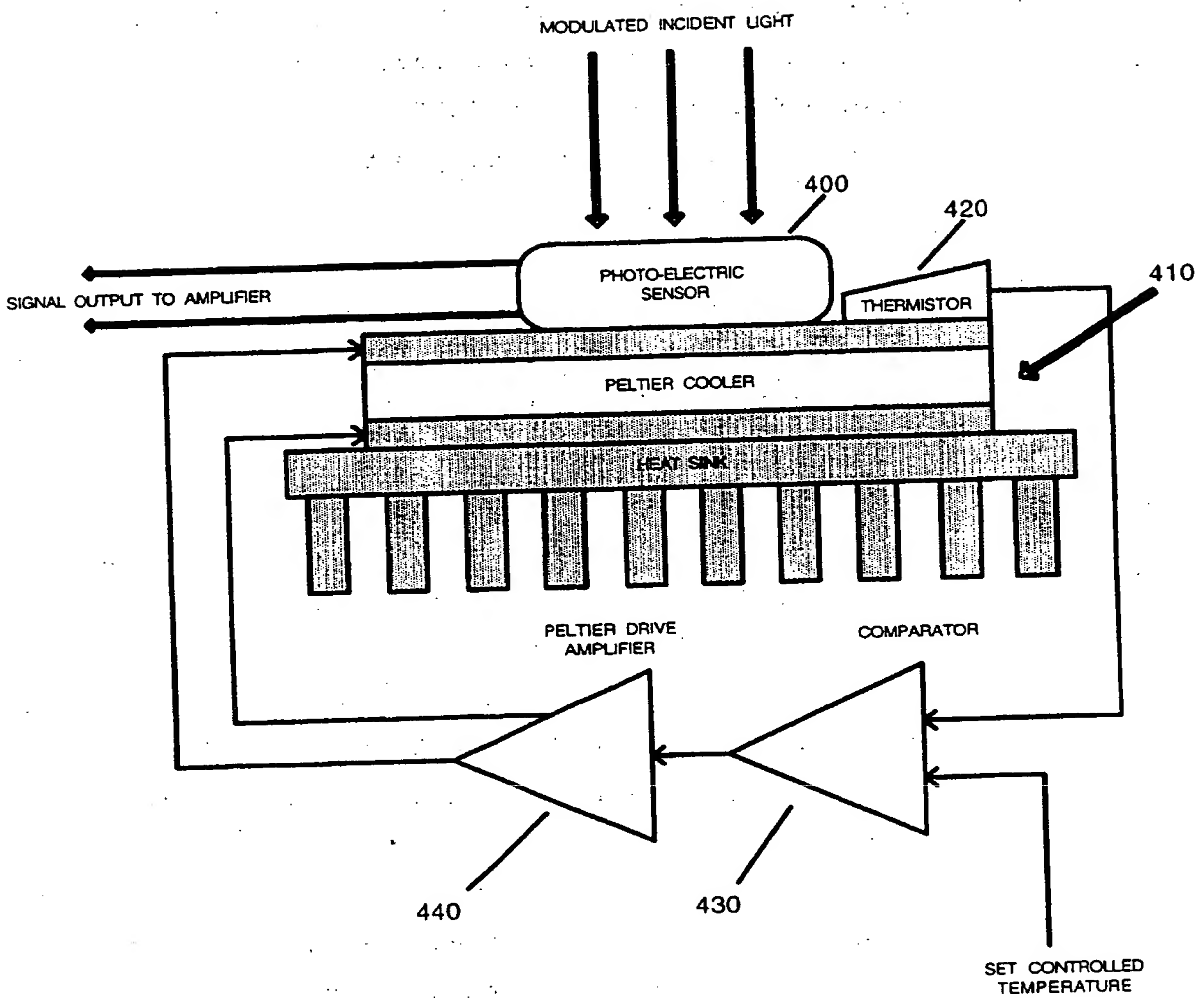
MODULATED INCIDENT LIGHT
400
420
410
PHOTO-ELECTRIC SENSOR
THERMISTOR
SIGNAL OUTPUT TO AMPLIFIER
PELTIER COOLER
HEAT SINK
PELTIER DRIVE AMPLIFIER
COMPARATOR
440
430
SET CONTROLLED TEMPERATURE

Fig. 5

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FILM SCANNER CORRECTION

This invention relates to correction of various errors which occur in film scanning. In particular, it relates to the correction of light level errors in a film scanner using a Cathode Ray Tube (CRT), caused by defects such as grain, blemishes, dirt, temperature changes, non uniformity and burn.

Defects of the type mentioned above can all cause the light level to vary unacceptably. Such problems are known in the field of CRT scanners and telecines which use a CRT to scan film for conversion to a video signal. These unwanted light variations cause a resultant unwanted modulation of the signal obtained in addition to the modulation caused by the film scanned. A description of flying spot film scanners may be found in Chapter 39 of "TV & Video Engineer's Reference Book", Millward J.D., edited by Jackson, K.G., and Townsend, G.B., published by Butterworth and Heinemann, ISBN 0 7506 19538.

An inherent disadvantage in using a cathode ray tube as a scanning light source is that the brightness of the tube can vary across the tube face. Such variations, may, for example, be due to phosphor thickness variations, solarisation of the glass envelope and or faceplate, phosphor screen ageing, phosphor burning, phosphor blemishes, or phosphor granularity variations in either a single crystal or mixed crystal(s) phosphor. They can lead to spurious variations in the brightness of light incident upon the film and thus ultimately spurious signals in the generated video signal or data. These problems are known and have been tackled in the prior art.

For example in UK Patent No. GB 1,566,910, an apparatus is described for correction of local variations in beam brightness in a CRT due to variations in phosphor, solarisation or burning effects. A block diagram of the main features of this prior art system is shown in Figure 1. The prior art implementation Shown in Figure 1, was embodied in the MKIII telecine product designed and manufactured by Rank Cintel Limited.

The system shown in Figure 1 is a scanner using a CRT (10) to produce a spot of light which is focused into film (30) through a lens (20). The CRT (10) produces broadband light of sufficient wavelength range to be considered as white. Accordingly, a first dichroic reflector (40) is positioned after the film to reflect the red component of light modulated by the film onto a photo detector (50). Similarly, a second dichroic reflector (42) reflects blue light modulated by a colour film (30) and transmitted through the first dichroic filter (40) to a second photo detector (54). Lastly green light transmitted by both dichroic reflectors (40;42) is received at a third photo detector (52). Each photo detector (50,52,54) produces an electrical output to a respective amplifier (50A,52A,54A) which amplifies each signal and provides the separate amplified colour signals to respective colour channels (60,62,64). This apparatus is well known in the art for providing three separate (red, green, blue) colour signals from film. The afterglow correctors which form part of the colour channels (60,62,64) are well known and readily understood by one skilled in the art, and together produce outputs Eg, Eb and Er respectively.

The prior art CRT telecine shown in Figure 1 also includes an additional photo detector (56)such as a Hamamatsu R2693 (side on window) and further circuity as will now be described, for correction of various unwanted illumination variations such as scan patches, non-uniformity and burn of the CRT. The additional photo detector (56) is positioned to receive light from the CRT (10) which is un-modulated by the film (30). Any variations in light level received by the additional photo detector (56) are, therefore, due to errors such as mentioned above. The output of the detector is amplified by an amplifier (56A), which includes an Automatic Gain Control (AGC) circuit (12) which operates to overcome temperature drift which may be introduced into the correction signal Ex produced by the amplifier (56A), or photo detector (56).

The correction signal required to apply to each colour signal Er, Eg and Eb is inversely proportional to Ex. Accordingly the multiplier (14) and amplifier (18) are arranged to provide this reciprocal function. The output of the multiplier (14) will be the product of it's two inputs and a gain factor N i.e. Ex.Vy.N. The resistive divider 16A and 16B produce a signal at the amplifier (18) input of $V+\frac{Ex.Vy.N.R}{N.R}$ which simplifies to V + Ex.Vy. As the amplifier (18) output is fed back in antiphase to the multiplier (14) input the circuit will tend to make the amplifier input equal to zero i.e. V+Ex.Vy = 0 which can be restated as $Vy = \frac{V}{Ex}$

The signal 1/Ex is fed to three separate potentiometer controls (80,82,84); one each for red, green and blue. These potentiometers (80,82,84) allow the level of

correction to be independently controlled for each of the red, green and blue channels. Three separate video multiplier circuits (70,72,74) each receive a respective one of the colour signals Er, Eg or Eb as well as the respective correction signal Kr/Ex, Kg/Ex or Kb/Ex (where K is the appropriate level of correction as adjusted by the potentiometers). The multiplier circuits (70,72,74) multiply the signals together to produce the outputs which are, for each respective channel:

$$Red=\frac{KrEr}{Ex} \quad Green=\frac{KgEg}{Ex} \quad Blue=\frac{KbEb}{Ex}$$

The prior art described above thus allows defects such as scan patches and non- uniformity to be corrected for a complete colour scan.

A second prior art system for correcting for illumination is known from GB-A-2,249,930. This patent discloses a system in which two identical additional detectors are used to detect light from the faceplate of a CRT to produce two correction signals. The more appropriate of the two signals is chosen to effect correction to eliminate spurious correction signals. Each additional detector samples broadband 'white' light from the CRT face to produce a correction signal for correcting the complete colour scan. The positioning of the additional photo detector (56) should not be too off axis otherwise parallax errors will be introduced in detecting dirt on the faceplate. It is known in the prior art that the implementation being herewith described, could be aligned either to maximise correction of general CRT intensity variations, or else to compensate for dirt on the CRT

faceplate, but these two requirements are mutually exclusive. The apparatus and method described in GB-A-2,249,930 overcomes this problem.

There are deficiencies with the above correction systems. In particular, the causes of unwanted illumination variation such as scan patches, time/temperature changes, dirt on the CRT face and drift, may produce illumination variation which differs across the wavelength. The resultant unwanted signals thus differ from channel to channel. The unwanted light variations may be independently corrected in each colour channel, by providing a separate additional detector to sample light from a CRT at separate wavelengths, in particular at red, green and blue. Such a scheme is suggested in German patent application DE 2,525,073, a third prior art system for correcting for illumination defects, which discloses that benefit may be gained from using multiple additional detectors 55, 59 and 57 as shown in Figure 2 in which there is a separate addition detector sensing the red, green and blue light from the cathode ray tube and applying each of these separately sensed correction signals to their respective colour channels 62, 64, 60 of Figure 2. The benefits of such independently sensed red, green, blue correction compared to the embodiment described in the first prior art are:-

i. Improved correction for brightness reduction due to previous scan patches.

ii. Improved reduction in visibility of granularity of the cathode ray tube screen.

iii. Improved reduction in screen blemish visibility.

iv. Improved reduction of visibility of dirt on the cathode ray tube faceplate.

If the separate additional detector 55, 59, 57 comprises photomultiplier then Automatic Gain Control (AGC) (12) will be required round each amplifier 100, 200, 300 for the reasons stated for the single detector (56) and amplifier (56A) of Fig 1.

The inadequacy of single burn correction sensor systems employing photomultipliers is known from the fact that with continuous motion flying spot telecine in which part of the vertical scanning of the film is brought about by the film motion itself, there comes a point with certain speeds of film motion where the patch on the cathode ray tube can be reduced to a single line. In this single line circumstance the CRT granularity is imprinted on the film image across all the scanned lines and appears as a pronounced fixed vertical stripe pattern on the image. Experimentation has shown that it is not possible to eliminate totally this stripe effect on all the colour channels concurrently simply by adjusting the gain controls (80), (84), (82) of the prior art typified by Fig 1. In fact to get the stripe effect eliminated on just one colour requires that a correction signal Ex is obtained by appropriate optical filtering of the sensor (56) so that it senses the CRT grain in the colour in which it is desired to eliminate the phosphor grain effects. Such an arrangement has been proposed in the third prior art dissertation.

It is also known that the production process of settling the ground phosphor out of suspension in a liquid on to

the inner CRT faceplate leads to a certain amount of clumping together of particles which also affects the scattering and hence visible emission of light when excited by an electron beam. Blemishes in the CRT phosphor stem from contamination during the manufacturing process. Non uniformity of the CRT phosphor coating may stem from inaccuracies in the settling out of ground phosphor from suspension and any enforced drying and baked adhesion processes which follow it. Dirt on a CRT faceplate may stem from handling but more importantly it occurs because the voltages which are applied to the CRT to produce sufficient light are typically 25-40KV which sets up an electrostatic field on the faceplate which subsequently attracts dust and other airborne particles.

Broadly the invention resides in providing light fluctuation correction which allows slow light fluctuations to be corrected. We have appreciated that using an additional sensor which is sufficiently stable that no automatic gain control is required, allows correction for such slow light level fluctuations to be made. By slow, we mean long term changes in illumination level which occur over seconds, minutes or hours, rather than fast fluctuations which occur in microsecond timescales.

Accordingly, there is provided an illumination corrector for a film scanner, the film scanner comprising: a cathode ray tube for illuminating film to be scanned; a first light sensor for receiving light modulated by the film to produce a first signal; the illumination corrector comprising: an additional light sensor for receiving light unmodulated by the film to produce a correction signal;

and means for combining the first signal and correction signal, to produce a corrected signal, wherein the additional light sensor is a stable sensor which requires no automatic gain control whereby slow light fluctuations are corrected.

The preferred embodiment also provides improved independent R, G and B correction of the RGB channels of a film scanner.

Embodiments of the invention will now be described, by way of example only, in which:

Figure 1 is a block diagram of a first prior art CRT telecine with a correction system to which the invention may be applied; and

Figure 2 is a block diagram of a second prior art CRT telecine embodying independent RGB correction to which the invention may be applied by way of example only;

Figure 3 is a table showing the advantages of the invention in comparison to the prior art of Figure 2;

Figure 4 is a table showing the advantages of the invention in comparison to the prior art of Figure 1; and

Figure 5 is a block diagram of the additional sensor and cooling device of the preferred embodiment.

In Figure 1, already described in detail, a prior art CRT telecine is shown having a single additional sensor (56) which receives broadband "white" light from a telecine CRT

unmodulated by film to provide correction. In this prior art, the red, green and blue outputs have been corrected for overall variation of the brightness of the scanning beam produced by the cathode ray tube and this correction (Kr, Kg, Kb) needed to compensate for the intensity variations in different parts of the colour spectrum of the CRT light. However, no correction is made for light variation which differs from channel to channel.

In Figure 2, like components have the same numbering as in Figure 1. The telecine comprises a CRT (10) such as a GU 2140 CRT manufactured by Brimar Ltd illuminating film (30) through a lens (20). Two dichroic reflectors (40,42) such as Dichroic relay optics reflect red and blue light respectively onto respective sensors (50,54) such as Hamamatsu Photo Multipliers type R2154 photo detectors, but allow transmission onto a third photo detectors (52) for green light. The photo detectors (50,52,54) provide signals to amplifiers (50A,52A,54A), here Transimpedance Amplifiers constructed from discrete components using BFR 90 and BFR 96 transistors which have outputs to afterglow correctors which form part of the colour channels (60,62,64) as previously described and used in the Rank Cintel Mk III telecine.

The optimised light variation correction solution embodying the invention has three additional sensors; one each for red (55), green (57) and blue (59) signals and which receive light from the CRT (10) via a respective red (155), green (157) and blue (159) filter. The additional sensors (55,57,59) are positioned to view light from the CRT without impeding the light path to the imaging lens (20). The red, green and blue filters provide light of wavelength ranges 600-685 nm, 510-590 nm and 440-490 nm

respectively, though other wavelength ranges may also be used and are within the scope of the invention.

For simplicity, the correction of illumination variation will only be described for one of the colour channels as correction in the other two channels is performed in an identical manner.

A colour of light passing through one of the optical filters (155,157,159) is received at one of the additional sensors (55,57,59) which produces an output to one of three amplifiers (100,200,300)which include afterglow correctors to improve the accuracy of the correction signal. Each amplifier (100,200,300) such as Video amplifiers constructed from BFR 90 and BFR 96 transistors produces an output signal Er', Eg' or Eb' respectively. Now light direct from the face of the CRT should have a constant illumination level. Any changes in the light level are, therefore, unwanted and are due to the various imperfections described before. As the sensors view the CRT (10) direct, these variations are detected and the resultant signals Er', Eg' and Eb' vary with changes in light level.

The implementation of the prior art with the generation of flying spot telecines exemplified by the Rank Cintel Limited MKIII telecine, revealed that the use of a photomultiplier for the additional photo detector (56) gave rise to an unacceptable amount of drift with temperature which was overcome by applying a peak detecting automatic gain control (12) to the correction signal Ex. This however, precluded this burn correction technique from correcting for absolute changes of CRT

brightness with time and temperature, any temporary brightness changes due to prior small scan patch such as occurs when zoomed in on the film, and any changes in brightness due to electron beam focus changes associated with dynamic focus or focus drift. This system has been described earlier and so the description will not be repeated here.

For the purpose of explanation the invention will be described by means of a CRT telecine as shown in Figure 2. However, it should be noted that the invention could apply equally to the system of Figure 1, or any film scanner whether or not it forms part of a telecine chain, and to a scanner used in a film writer in which a signal is applied to a CRT for writing to film. In a film writer, systematic defects such as burns, blemishes or grain on the CRT face would be corrected in each colour channel by storing a "map", in a framestore of the CRT face as detected by each correction sensor. The separate colour signals could then be corrected in accordance with each map. The use of a correction map is described in our European patent No. EP-A-0,449,875.

An alternative system which may be used in a film writer is to feedback the signal from the correction sensor to modulate the drive signal to the CRT such as to cancel the unwanted illumination effects. The signal from the sensor would be compared with the input video signal and the result used to increase or decrease the drive to the CRT so as to make the CRT brightness equal to the input video signal.

In the case of a sequential colour scan film writer it is only necessary to have one correction sensor which would be fitted such as to view the CRT face through the colour filter wheel.

Although the embodiment described uses analog electronics, it should be noted that the invention could equally be applied in a digital telecine, and this is within the scope of the invention.

The choice of additional light sensor is constrained by various factors. Photomultipliers are generally too large and are prone to thermal and light exposure memory drift which leads to differential effects making them generally unsuitable for three colour correction. Solid state photodiodes do not suffer these problems. However, the optical filters (155,157,159) do not allow sufficient light from a CRT to provide adequate signal to noise performance. Avalanche Photo Diodes (APD) are more suitable devices, such as the Advanced Photorix Inc. 394-70 APD. Those are small, have a reasonably flat spectral response, have zero post-illumination memory, are immune to magnetic field disturbance and have very high quantum efficiency. Accordingly, the above APD is chosen for the optimum solution embodiment.

The appropriate correction signals are produced by processing circuity comprising, for each colour channel, wide band multipliers (110,210,310) type MC 1496 differential amplifiers (120,220,320) Elantec type EL 2073, resistors (16A,16B) and scaling controls (140,240,340) which are variable resistors to produce

independent red, green and blue correction signals Vr, Vg and Vb, which are expressed as:

$$Vr=\frac{Kr}{Er'} \quad Vg=\frac{Kg}{Eg'} \quad Vb=\frac{Kb}{Eb'}$$

Each correction channel is similar in operation to that previously described in respect of Figure 1. However, by having three separate correction channels, one for each colour, it can be seen that the correction signals are independent and correct for illumination variations which differ from channel to channel. The factors Kr, Kg and Kb are parameters which may be varied using the scaling controls (140,240,340) to adjust the overall level of correction in each channel.

The outputs Vr, Vg and Vb are then applied to video multipliers (70,72,74) for example type SG 1496 T video multipliers which multiply the colour signals Er, Eg and Eb with the correction signals Er', Eg' and Eb' to produce corrected colour output signals which are

$$Red=\frac{ErKr}{Er'} \quad Green=\frac{EgKg}{Eg'} \quad Blue=\frac{EbKb}{Eb'}$$

The advantages of Avalanche Photo Diode triple sensor correction over the prior use of photomultiplier sensors, will now be described with reference to the Table 1.

It will be noted that the APD correction sensor optimised solution achieves correction of E, F, G, which are not corrected with a triple photomultiplier implementation.

Consider first the general cause of a disturbance in the light level on the CRT scan from whatever cause. In the prior art systems, the disturbance will be picked up by the additional sensor, a correction signal(s) produced, and correction applied to all three colour channels. Each of the specific causes of unwanted illumination variation will now be considered in turn. In cases E, F, G correction is improved with the embodiment of the invention.

In case H, where the brightness of the CRT is generally non-uniform, the single photomultiplier sensor prior art system will provide some correction, but will not take account of such variation varying with wavelength i.e. from one colour channel to another. In the triple sensor embodiments including the invention, the general variations are measured for each colour and so are properly corrected. Similarly in case A, in which previous scan patches cause a reduction in brightness, the correction is improved with the triple sensor embodiments. The scan patch varies in size depending upon the speed of the film through the telecine. The faster the film moves through the telecine, the smaller the patch required to scan it. Over time, patch sizes which are regularly scanned will alter in characteristics both of the luminance of the phosphor and the colour. The prior art single photomultiplier sensor correction would compensate for the overall luminance change, but would not compensate for colour change as in the present embodiment of the invention.

The scan patch size is also a problem in temporary scan patch changes, as in case F. In this case, the luminance

and colour of the phosphor is temporarily changed due to a small scan patch. The small scan causes a build up of heat which affects the phosphor characteristics. The characteristics are also altered with time and overall temperature as in case E. In case G, the focus changes and drift in the electronic circuits can also cause coloured variations.

In all three cases E, F and G, the unwanted colour variations are not corrected in prior art photomultiplier sensor correction systems. This is because auto gain control (12) is required to correct for drift in the detectors (56). Any variations, such as E, F and G, which are longer term changes, are not properly corrected in the photomultiplier sensor correction prior art, because the AGC (12) filters out such changes before generation of the correction signal. The AGC was required to prevent drift in the photo multiplier sensor (56) from being included in the correction signal.

The timescales involved with the variations in light intensity E, F and G are of the order of seconds, minutes and hours. Changes with time and temperature E occur during the use of a telecine during a film transfer session which is typically a number of hours. The changes occur over minutes or hours, and so are not corrected in the prior art since the AGC in the additional detector circuitry will compensate for these changes and so the correction signal will not provide correction at their timescales.

The temporary changes due to prior small scan patches F occur as the scan patch is reduced which can temporarily

affect the brightness of a small area of phosphor. The phosphor in this area may take around 10 to 30 seconds to re-establish the luminance level of the remaining CRT face. The embodiment of the invention corrects for variations in these timescales.

Drift and focus changes G can occur over minutes or hours, and are corrected in the embodiment of the invention.

The illumination variation caused by disturbance of the CRT face such as granularity, blemishes, dirt and general non-uniforming B,C,D and H all cause fast illumination variation. The spatial frequency of the variation on the CRT face is related to the temporal frequency of the illumination variation by the rate of scanning. In cases B, C and D this causes light fluctuation over microsecond timescales. Since the AGC does not react over these times, these disturbances are corrected in the prior art. Similarly, permanent changes H have disturbance timescales of around 40 microsecond in the horizontal scan direction and 30 millisecond in the vertical. In all cases B,C,D and H improved correction is delivered with the embodiment of the invention.

Brightness reduction due to previous scan patches A occurs due to changes in the phosphor and occurs over a timescale of days. The embodiment of the invention provides improved correction.

In the embodiment of the present invention, use of APD devices as the additional sensors (55, 57, 59) which are more stable, allows the AGC (12) to be omitted, and hence the long term changes E,F and G to be corrected. To

optimise the performance of the APDs, it is best to control them thermally by a Peltier cooler. By making the sensors thermally stable, the automatic gain control may be omitted. Thus, the embodiment of the invention provides correction for the changes E, F and G not previously provided for, and provides it for coloured defects by correcting individually for each channel.

Referring to Figure 5, the Photo electric sensor 400 (in this case Avalanche Photo Diode) is thermally connected to the cool side of a Peltier Cooler 410. When the Peltier Cell has a suitable voltage applied across it's terminals, heat is moved from the cool side to the hot side where it is dissipated by a heat sink. The amount of heat removed can be controlled by the applied voltage. A thermistor 420 is attached to the cool side such that it gives a measure of the apd temperature. This temperature measurement is compared in the comparator 430 to a preset required temperature value. If the apd temperature exceeds the set point then a signal is applied to Peltier Drive Amplifier 440 so as to increase the voltage applied to the Peltier Cell which will in turn remove more heat and reduce the temperature of the apd. The converse applies if the apd temperature is below the set point. By this means the temperature of the apd is maintained within less than one degree Celsius of the set point.

The apd, Peltier Cell, and thermistor can be obtained in one package (e.g. Advanced Photonix Inc. Part number 394-70-74-551) an advantage of this system being that the small dimension of the cooled parts results in less heat removal being required. A suitable comparator is the Burr Brown Instrumentation Amplifier INA114. The Peltier Drive

Amplifier can be constructed for example using industry standard operational amplifiers such as the 741 and power transistors such as the Motorola TIP29a.

Granularity, blemishes and dirt on the CRT faceplate, listed as B, C and D in the table cause sudden variations which are likely to be coloured and so are particularly improved in the present embodiment of the invention. In the single photomultiplier sensor correction prior art, the timing of the correction signal required adjustment to switch between two modes: (i) to correct B and C, or (ii) to correct D. This is because granularity and blemishes occur on the phosphor on one side of the CRT faceplate, whereas dust is on the other. This causes a difference in time of the two effects and so a choice was made to correct for grain and blemishes, or for dirt. In the present embodiment, a thick faceplate CRT is used which defocuses dust on the surface, reducing the unwanted signals caused by dust, and allowing the timing to be set for good correction of grain and blemishes. Hence, all three causes of illumination variation; grain, blemishes and dust are all corrected better and for each colour channel individually. In particular, the granularity has a different structure in the three colours red, green and blue which is corrected in the present embodiment. These B, C, D, benefits with the invention embodiment equally apply to the triple photomultiplier sensor correction case.

An alternative embodiment of the invention would replace the use of three optical filters (155), (157), (159) in front of the APD detectors (55), (57), (59) by a lens and reflective dichroic mirror system such as already

identified for (20), (40), (42) and their associated equivalent sensors (50), (52), (54).

For clarity of description Figure 2 shows the burn correction being derived and applied by analog circuitry. An alternative embodiment within the scope of the invention would use digital circuitry, incorporating Analog to Digital Converters immediately following the afterglow correctors which form part of the channels (60,62,64), and the correction signal afterglow correctors and amplifiers (100,200,300). The analog reciprocal circuits (110), (120), (210), (220), (310), (320) would be replaced by digital look-up tables, and the video multipliers (70), (72), (74) would be replaced by digital multipliers. This embodiment has greater stability, and less alignment requirements leading to improved accuracy over its analog equivalent. Notwithstanding these preferred locations, the burn correction may be applied at any suitable stage of the scanner electronics.

Adoption of an APD for the additional detector (56) of Fig 1 would permit correction of cases E, F, G of the Table 1 to be achieved as set forth in Table 2. The detailed explanation of the causes and benefits to this solution have been already discussed for the triple sensor case.

Alternative stable additional detectors for which no AGC is required may also be suitable, and are within the scope of the invention. Other variations and modifications within the scope of the invention are possible and will be understood by those skilled in the art. The invention is limited only by the following claims.

CLAIMS

1. An illumination corrector for a film scanner, the film scanner comprising:

a cathode ray tube for illuminating film to be scanned;

a first light sensor for receiving light modulated by the film to produce a first signal;

the illumination corrector comprising:

an additional light sensor for receiving light unmodulated by the film to produce a correction signal; and

means for combining the first signal and correction signal, to produce a corrected signal, wherein the additional light sensor is a stable sensor which requires no automatic gain control whereby slow light fluctuations are corrected.

2. A telecine comprising a film scanner and illumination corrector,

the film scanner comprising:

a cathode ray tube for illuminating film to be scanned;

a light sensor for receiving light modulated by the film to produce a first signal;

the illumination corrector comprising:

an additional light sensor for receiving light unmodulated by the film to produce a correction signal; and

means for combining the first signal and correction signal to produce a corrected signal, wherein the additional light sensor is a stable sensor which requires

no automatic gain control whereby slow light fluctuations are corrected.

3. An illumination corrector according to claim 1 or 2, wherein the first light sensor receives light of a first wavelength band, the additional light sensor receives light of the same first band and the corrected signal is a first corrected colour signal, the film scanner further comprising:

second and third sensors to receive light of second and third wavelength bands to produce second and third colour signals, the corrector further comprising second and third additional light sensors to receive second and third wavelength bands to produce second and third correction signals; and

means for combining the second colour signal and second correction signals the third colour signal and third correction signal to produce second and third corrected colour signals, wherein the first, second and third wavelength bands are red, green and blue.

4. An illumination corrector according to claim 1, 2 or 3 wherein the additional sensors are placed to view the CRT face.

5. An illumination corrector according to any preceding claim, wherein the additional sensors are Avalanche Photo Diode (APD) devices.

6. An illumination corrector according to any preceding claim, wherein the means for combining the colour signals and the correction signals comprise video multipliers.

7. A telecine according to claim 2, wherein the cathode ray tube comprises a thick faceplate.

8. An illumination corrector according to any preceding claim, wherein the timescale of slow light fluctuations is seconds, minutes or hours.

9. An illumination corrector according to claim 5, wherein the APD is cooled by a Peltier cooling device.

10. A telecine substantially as herein described with reference to Figures 3, 4 and 5.

The Patent Office

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Application No: GB 9713681.6
Claims searched: 1-10

Examiner: John Coules
Date of search: 5 August 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4F FCD,FHHX,FHHB

Int Cl (Ed.6): H04N 3/36,3/38,3/40,5/253,5/257,9/11

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2249930 A (RANK CINTEL) see whole doc	1 & 2 at least
X	GB 1566910 (RANK) see whole doc	1 & 2 at least
X	DE 2525073 A1 (RANK) see whole doc	1 & 2 at least
X	IBM Technical Disclosure Bulletin. Vol 5,No 8, Jan 1963,pages 110-111	1 & 2 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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